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for the Behavioral and Social Sciences**

Research Report 1838

**Digital C3 Systems: Patterns of Use
in an Operational Environment**

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U.S. Army Research Institute

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Research Report 1838

**Digital C3 Systems: Patterns of Use
in an Operational Environment**

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FOREWORD

Digital, networked Command, Control, and Communications (C3) systems are being employed in current operational environments. Digital C3 systems provide an improved information flow, which makes it possible to quickly plan, coordinate, and execute operations at an increased operating tempo. Such improved information flow can aid in making U.S. forces more effective and survivable.

The effectiveness of this new technology relies on its skilled application. Leaders and Soldiers must learn the best ways to apply digitization in order to gain the anticipated tactical advantages. Formal training in digital systems provides an essential foundation for this learning. However, the current operations tempo of the U.S. Army puts training time at a premium. Therefore, training must focus on those skills leaders and Soldiers need most in an operational environment.

This research identifies those digital C3 functions Soldiers report employing most often in the field, and includes Soldier opinions of how difficult the functions were to learn and perform. The results of this research can be used to focus scarce training resources and time on those digital skills, which have the greatest impact on unit performance.

The work described in this report is a portion of research task 234, Defining and Measuring Digital Skill Proficiency, sponsored by Program Executive Office for Simulation, Training, and Instrumentation (PEOSTRI) Project Manager for Training Devices. The results of this work were briefed to the instructors of the III Corps' Battle Command Training Center at Fort Hood, Texas on 19 April 2005.



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DIGITAL C3 SYSTEMS: PATTERNS OF USE IN AN OPERATIONAL ENVIRONMENT

EXECUTIVE SUMMARY

Research Requirement:

The U.S. Army's use of networked digital C3 systems has the potential to effect substantial improvements in how military operations are conducted. However, to capitalize on the benefits of digitization, units must invest considerable effort to train Soldiers in the skills they need to exploit the advantages of digital systems. Given that training time is often a scarce resource, it is important to understand how digital C3 systems are employed by Soldiers in the field so that training can focus on those skills needed most by Soldiers. The present research explores how leaders and Soldiers use digital C3 systems in an operational environment.

Procedure:

A set of questionnaires was administered to 11 Soldiers with operational experience with several digital C3 systems. The questionnaire asked Soldiers to rate over 30 C3-related functions, which can be performed using digital C3 systems. Soldiers rated whether they preferred to perform each function using digital or manual means, how frequently they performed each function, how hard each function was to learn to perform, and how hard each function was to perform in the field.

Findings:

Soldiers use approximately one-half of digital C3 functions "occasionally" or more often, while the other half of available functions are rarely used. The functions used frequently include classic C3 planning and reporting tasks. Of the more frequently used functions, some were rated as easy to learn or use and some were rated hard to learn or use. There were significant correlations between ratings of functions that suggest Soldiers preferred using digital means for the functions they used most often, that they tended not to use functions which were hard to perform or hard to learn, and also that they felt functions that were hard to learn tended to be hard to perform also.

Utilization of Findings:

These findings can be used by trainers to decide what digital functions are used most often, are more difficult to learn and use, and thus require the most training emphasis. In addition, this information identifies those functions that are difficult to use and therefore may be used by program managers to improve system usability.

DIGITAL C3 SYSTEMS: PATTERNS OF USE IN AN OPERATIONAL ENVIRONMENT

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DIGITAL C3 SYSTEMS: PATTERNS OF USE IN AN OPERATIONAL ENVIRONMENT

Introduction

Digital Command, Control, and Communications (C3) systems provide a number of advantages to U.S. Army units who use them. They can provide a Common Operational Picture (COP) to units both internal and external to a military echelon, significantly increasing the Situation Awareness (SA) of leaders and Soldiers in the units (Barnett, Meliza & McCluskey, 2001). They can also speed the production and distribution of orders, reports, and battlefield graphics, which can increase the operations tempo (Barnett, Meliza & McCluskey, 2001) and allow friendly units to act faster than enemy forces can react.

The promise of digital C3 systems can only be realized if leaders and Soldiers have the training and experience to exploit its advantages. Learning how to employ digital systems correctly is a complex and time-consuming process.

The purpose of this research was to determine how Soldiers used digital C3 systems in an operational environment and use this information to suggest refinements to the curriculum of formal training programs. Training developers wanted to know what digital functions and tools Soldiers relied upon, and which they found of little use. They also wanted to know how often certain functions and tools were used, how hard they were to learn, and how hard they were to use. Such information could be used to focus training on those functions and tools that were used most often, and those which were difficult to learn and to use.

The next section provides some background on digital C3 systems and digital training. Following sections discuss the method used to perform the research, present the results, and discuss the implications of the findings.

Background

Digital C3 Systems

A number of U.S. Army units utilize networked C3 computer systems. These computer systems apply automation to help leaders perform many of the C3 functions previously accomplished manually, such as distributing orders and reports, and creating and distributing battlefield graphics.

Information on the tactical situation can be distributed over the network from command centers down to the lowest-level combat formations, which use the information to gain a tactical advantage. Digitization not only increases combat capabilities, but also improves safety by reducing the chances of fratricide or "blue on blue" incidents. In addition, combat units who use digital systems are expected to maintain better SA and to plan and execute operations more quickly than non-digital units (Barnett, Meliza, & McCluskey, 2001).

Digitization serves as a decision-support system for combat commanders. It helps them visualize the battle space and presents needed information in a format that fosters the

commander's SA. Digitization also provides analytical tools, such as terrain analysis tools and automated warnings that can further enhance SA.

There are a number of different digital systems. Some of the systems are designed to fulfill a specific function, while others perform generic C3 functions. For example, the All Source Analysis System (ASAS) is designed specifically to share intelligence data, whereas the Force XXI Battle Command, Brigade and Below (FBCB2) performs a wide range of C3 functions. What all these systems have in common is they distribute essential C3 data over a network.

Digitization Training

Formal training for most digital systems is conducted at the Battle Command Training Center (BCTC) at Fort Hood, TX. BCTC provides Operator New Equipment Training (OPNET), leader training, and staff officer training for a number of different digital systems. Because of the large number of digital operator positions and limited training resources, many digital operators do not attend formal training and instead learn to use the system through on-the-job training or apprenticeship-type learning. Some operators attend formal training after using the systems for a period of time.

Training for many of the systems consists of around forty hours of instruction on digital workstations connected by a simulated network. Instruction focuses on performing common functions and using tools specific to the particular digital system. Training proceeds through a number of lessons, typically including a description of systems components, preparation for combat, movement operations, assembly area operations, deliberate attack, consolidation and reorganization, and troubleshooting. Since little information is available about how often certain functions are used in an operational environment or how difficult it is to learn or perform digital functions, each of the functions receives equal training emphasis. The purpose of the current research was to collect data on how digital systems were used in an operational context so that training could be updated to reflect realistic employment of the systems.

Method

Participants

Eleven Soldiers participated in the research. They ranged from Specialist/Corporal (E4) to Captain (O3), with between one and 12 years of service ($M = 4.8$, $SD = 3.43$). Most participants had field experience in Operation Iraqi Freedom (OIF), but some did not. Six of the eleven participants reported attending a formal training class for their particular digital system, while the rest reported learning through on-the-job training and watching others. Those who attended formal training also reported learning through on-the-job training and watching others as well. Eight had operated FBCB2, and five reported operating more than one digital system. They reported using digital systems in echelons from Platoon through Corps.

Apparatus

The apparatus consisted of a set of two questionnaires, one for users of FBCB2, and one for users of digital systems normally found in Tactical Operations Centers (TOC). Both questionnaires asked similar questions about how Soldiers used features of the digital systems. The FBCB2 questionnaire asked additional questions specific to FBCB2.

The first section of the questionnaires asked for demographic data. The second section provided a list of functions that could be performed on the digital systems and asked Soldiers whether they preferred to perform the function digitally or manually, how often they performed the function, how difficult it was to learn to perform the function, and how difficult it was to perform the function. The list was developed by digital training instructors at the BCTC and represents functions common to both TOC digital systems and FBCB2, as well as functions specific to each of these systems. In all, the questionnaires asked about 38 functions; 24 were common to all systems, seven were TOC only functions, and seven were FBCB2 specific functions. Table 1 lists the digital functions included in both questionnaires and indicates those that were common functions, TOC only, or FBCB2 only functions. The last section of the questionnaire asked a series of free-response questions.

Table 1. *Digital Functions Included in Questionnaires*

DIGITAL FUNCTIONS	DIGITAL SYSTEM
Send/Receive Information	
Create/send/receive reports	Common
Create/send/receive orders	Common
Create/send/receive graphics/overlays	Common
Create/send/receive free text messages	Common
Call for support (general)	Common
Distribute graphics/overlays	Common
Report logistics status	Common
Report personnel status	Common
Distribute plans and orders	TOC systems only
Call for fire	FBCB2 only
Distribute other data	FBCB2 only
Planning Functions	
Plan routes	Common
Perform terrain analysis	Common
Check trafficability of routes	Common
Develop plans and orders	TOC systems only
Coordinate plans and orders	TOC systems only
Synchronize tasks between units	TOC systems only
Synchronize support actions	TOC systems only
Use task management tools	FBCB2 only function
Situation Awareness	
Check location of friendly units (from your unit)	Common
Check location of friendly units (from other units/allies)	Common
Check location of civilians	Common
Check location of enemy units	Common
Check location of obstacles	Common
Check location of key support points (e.g., FAARP, etc.)	Common
Check location of other areas of interest (not covered above)	Common
Check personnel status of your units	Common
Check logistics status of your units	Common
Avoid firing on friendly units	Common
Check supplies available at CSS location	Common
Check that units are following plan/branches/sequels	Common
Use reminders	Common
Manage logistics	TOC systems only
Manage personnel actions	TOC systems only
Use alarms	FBCB2 only function
Navigation	
Navigate routes	FBCB2 only function
Navigate in low visibility	FBCB2 only function
Navigate in complex/urban terrain	FBCB2 only function

Procedure

As participants entered the classroom, they were welcomed by the researcher and briefed on the purpose of the research and on confidentiality measures. The researcher then determined which participants had experience with only the FBCB2 system. These were given the FBCB2

questionnaire. Participants who had experience with one or more TOC system were given the TOC questionnaire. Participants were allowed to ask questions of the researcher, and were allowed as much time to complete the questionnaire as needed. As each respondent completed the questionnaire, the researcher collected it and thanked the participant for his or her involvement in the research.

Limitation of this Research

There are several limitations to this research. The major shortcoming to this effort was that relatively few Soldiers participated. Although a larger number of participants were planned, the current operations tempo of the U.S. Army reduced the number of participants available, so that the final number of participants was eleven. Of this number, eight completed the TOC questionnaire, and three completed the FBCB2 questionnaire. Although this number is relatively small, some of the participants were highly experienced with digital C3 systems and were able to provide excellent data, particularly in the free response section.

In addition, some participants did not answer all the questions. A few participants reported they felt they did not have enough experience with digital systems to answer all the questions, therefore, they left some question blank. This further reduced the *N* for certain questions.

Results

Participant Demographic Information

All but one participant reported owning a personal computer (PC), and all who owned a PC reported they had Internet access. They stated they operated a computer an average of 15.9 hours a week ($SD = 7.9$). All claimed to be familiar with at least one common office software package. When asked how often they used common office software (Word, Excel, Powerpoint, etc.) 55% responded "occasionally" or "fairly often" while 45% responded "all the time."

Respondents all reported playing computer games. When asked which gaming systems they had used (PC, X-Box[®], Playstation/2[®], Gamecube[®]) and which they preferred, 64% reported using multiple systems, with the majority (73%) preferring the Playstation[®] or Playstation 2[®] controller.

Several demographic variables were correlated using the Pearson Product Moment correlation function of a statistical software package (Information Technology Services, University of Texas at Austin, 2004). The only significant correlation was a positive relationship between years of service and PC hours ($r = .679, p < .022$).

Digital Usage Questions

Function preference. The first question presented the Soldiers with a list of functions that could be performed on digital systems. For each function, they were asked to check whether

they preferred to use the digital system to perform the function or complete the task using other than digital means.

The percentage of respondents who preferred digital versus non-digital means for each function was calculated and the results grouped into sections. The first group included functions where 25% or less of the participants preferred digital means, the second group included functions where between 26% and 50% preferred digital, the third group included functions where between 51% and 75% preferred digital, and the fourth group included functions where greater than 75% of participants preferred to use digital means to perform the function. Grouped this way, functions that fall in the first group indicate a distinct preference for non-digital means to perform the function, while those that fall in the fourth group show a definite preference for digital means.

Due to an error on the questionnaire, only 31 of the 38 functions were rated for function preference. Of these, five fell in the fourth group (definite digital preference); "Navigate in complex/urban terrain," "Check location of friendly units (from your unit)," "Check location of friendly units (from other units/allies)," "Create/send/receive graphics/overlays," and "Check location of key support points." Fifteen functions fell in the third group (slight preference for digital), and eight functions fell in the second group (slight preference for non-digital). The first group (significant preference for non-digital task performance) had three functions.

A comparison between preference for digital or manual for each of the functions and whether the Soldiers attended classroom training (as compared to on-the-job training) was performed for each of the functions using the Phi coefficient (Siegel & Castellan, 1988). Somewhat surprisingly, there were no significant relationships between classroom training and preference for performing functions digitally or manually.

Frequency of use. The next section presented respondents with the list of digital functions and asked them to rate how often they used each function. They were asked to rate the functions on a four-point scale as to whether they "never used it," "used it occasionally," "used it often," or "used it most of the time." The results are shown in graph B-1 in Appendix B, and also in Table 2.

For all 38 functions, including common functions, TOC specific functions, and FBCB2 functions, Soldiers reported using 19 (50%) of the functions "occasionally" or more often. The other 50% they reported they rarely used. Fourteen functions (37%) they said they used "occasionally;" two (5%) they used "often," and three (8%) functions were used "most of the time."

Difficulty in learning to use the function. Question 3 presented the same set of digital functions and asked the participants to rate how difficult it was to learn to use each of the functions. Again, a four-point scale was used, and participants could choose between "very easy to learn," "easy to learn," "somewhat hard to learn," and "very hard to learn." The results are presented in graph B-2 in Appendix B as mean and mode responses, and also shown in Table 2.

Of 38 functions Soldiers rated, 4 (11%) were rated "very easy" to learn, 18 (47%) were rated "easy," 10 (26%) were "hard," none were rated "very hard," and 6 (16%) functions showed disagreement as to whether the function was hard or easy. These figures are based on mode responses.

Difficulty of use. The fourth question asked how difficult the functions were to use. Soldiers were asked to rate the same set of digital functions or functions as "very easy to use," "easy to use," "somewhat hard to use," or "very hard to use." Means and mode responses to this question are presented in graph B-3 in Appendix B, and in Table 2.

Table 2. *Summary of Ratings for Digital Functions*

Function	Digital Preference ^a	Frequency of Use ^b	Difficulty Learning ^c	Difficulty Performing ^d
Create/send/receive reports	60%	1.73	2.00	2.25
Create/send/receive orders	44%	1.18	2.11	2.25
Create/send/receive graphics/overlays	90%	2.09	2.30	2.22
Create/send/receive free text messages	66%	1.45	1.90	1.78
Call for support (general)	43%	0.33 ^e	2.3 ^e	3.0 ^e
Distribute graphics/overlays	66%	0.66 ^e	3.0 ^e	3.0 ^e
Report logistics status	62%	0.45	1.75	2.50
Report personnel status	50%	0.45	1.75	2.50
Plan routes	60%	1.66 ^e	2.0 ^e	2.5 ^e
Perform terrain analysis	55%	0.55	2.13	2.50
Check trafficability of routes	55%	0.73	2.00	2.20
Check location of friendly units (from your unit)	90%	1.91	1.38	1.71
Check location of friendly units (from other units/allies)	90%	1.45	1.43	2.00
Check location of civilians	33%	0.36	2.00	3.00
Check location of enemy units	66%	0.73	1.71	2.17
Check location of obstacles	57%	1.00	2.00	2.33
Check location of key support points (e.g., FAARP, etc.)	87%	0.66 ^e	2.33 ^e	2.33 ^e
Check location of other areas of interest (not covered above)	71%	0.56	2.13	2.50
Check personnel status of your units	25%	0.45	1.75	2.50
Check logistics status of your units	37%	0.45	1.75	2.50
Avoid firing on friendly units	62%	1.33 ^e	2.0 ^e	2.33 ^e
Check supplies available at CSS location	40%	0 ^e	3.0 ^e	4.0 ^e
Check that units are following plan/branches/sequels	40%	0.20	3.00	4.0 ^e
Use reminders	0% ^e	1.00	1.86	1.75
Distribute plans and orders (TOC specific)	-	0.63	1.20	1.75
Develop plans and orders (TOC specific)	-	1.50	1.75	2.00
Coordinate plans and orders (TOC specific)	-	0.75	1.50	1.75
Synchronize tasks between units (TOC specific)	-	0.75	1.50	2.00
Synchronize support actions (TOC specific)	-	0.75	2.25	2.00
Manage logistics (TOC specific)	-	0.25	2.50	3.00
Manage personnel actions (TOC specific)	-	0.13	2.00	3.00
Distribute other data (FBCB2 specific)	71% ^e	0.66 ^e	3.0 ^e	3.0 ^e
Call for fire (FBCB2 specific)	55%	0.66 ^e	2.33 ^e	2.5 ^e
Use task management tools (FBCB2 specific)	0% ^e	0.66 ^e	3.0 ^e	3.0 ^e
Navigate routes (FBCB2 specific)	66% ^e	1.33 ^e	1.5 ^e	2.5 ^e
Navigate in low visibility (FBCB2 specific)	66% ^e	0.66 ^e	2.0 ^e	2.5 ^e
Navigate in complex/urban terrain (FBCB2 specific)	100% ^e	1.0 ^e	2.0 ^e	2.5 ^e
Use alarms (FBCB2 specific)	50% ^e	0.33 ^e	2.0 ^e	2.0 ^e

^a Percentage of Soldiers who prefer to perform the function using digital means.

^b Higher numbers indicate more frequent use.

^c Higher numbers indicate the function was more difficult to learn to use.

^d Higher numbers indicate the function was more difficult to use.

^e Rating based on $n \leq 3$.

Soldiers rated 38 functions for difficulty of use. Of these, none were rated "very easy," 14 (37%) were rated "easy," 12 (32%) were "hard," two (5%) were "very hard." Ten functions (26%) were multi-modal and a rating could not be determined. Note that some of the ratings are

based on three or less responses. Table 2 identifies which ratings had a low response rate ($n \leq 3$).

Summary of function ratings. Table 2 presents each digital function with the scores for each of the four ratings; preference for digital or manual, frequency of use, difficulty of use, and difficulty of learning to perform the function. The digital preference rating is the percent of Soldiers who prefer to perform the function using digital means. The other three ratings are the mean scores. Not all functions were rated for digital preference; dashes indicate this missing data.

Relationship between function ratings. To determine how these four factors (digital preference, frequency of use, difficulty learning, and difficulty using digital functions), were related, mean ratings for the functions were correlated using the Spearman Rho correlation. This analysis found there was a significant positive correlation between frequency of use of a function and preference for using digital means to perform that function ($r_s = .558, p < .01$, two-tailed) which suggests Soldiers preferred digital means for functions they used most often.

Also, there were significant negative correlations between how frequently Soldiers used a function and how difficult it was to learn to use it ($r_s = -.335, p < .05$, two-tailed), and to use it ($r_s = -.631, p < .01$, two-tailed), meaning they tended not to use functions that were hard to learn or use. Finally, there was a significant positive correlation between how difficult Soldiers thought the function was to learn to use and how difficult it was to use ($r_s = .646, p < .01$, two-tailed), which means functions that were hard to learn tended to be hard to use also.

Free Response Questions

The second section of the questionnaire asked for a free response to a number of questions. The questions were the same for the TOC and FBCB2 questionnaires, but additional, FBCB2-specific questions included on the FBCB2 questionnaire. Not all participants responded to the questions, but many did. Summaries of responses are shown below. The verbatim responses are included in Appendix C.

Question 5 – “Were there any functions you would have liked to use but didn’t because you didn’t know how? If so, which ones?”

Summary. Two participants said there were no functions they did not use because they did not know how. Three participants noted that there were probably functions they did not use because they did not have formal training in the systems and did not know the full system capabilities. Two participants mentioned functions or tools in one system (such as Falcon View) that they wished were available in other systems (such as ASAS). One respondent said he would have like to have used “sequels” but did not know how.

Question 6 – “Were there any digital procedures you forgot how to use if you didn’t use them often enough? Which ones? Did you use any reference (such as the on-line tutorial or software user’s guide) to remember?”

Summary. Eight respondents said certain procedures were perishable. One said most skills with the Air and Missile Defense Warning System (AMDWS) were perishable. Three Soldiers said they would refer to references and user's guides to remember how to perform functions. One said the user's guide went too much in depth to be used quickly. The perishable skills listed were; configuring the Electronic Data Interchange (EDI) node initialization, proper start up and trouble shooting procedures (AMDWS), using the terrain analysis tools, developing a plan of action, keeping passwords current, setting up Advanced Field Artillery Tactical Data System (AFATDS) to receive targets for Q-36 and Q-37 radars, call for fire, call for support, navigation in low visibility, graphic overlays, send/receive map overlays.

Question 7 – "What part of operating digital systems should digital training focus on?"

Summary. Respondents had a number of different opinions as to what training should focus on. Some listed specific functions, while others mentioned general procedures such as troubleshooting or maintaining connections to the network. One participant said training should focus on functions that do not get used in normal training, and noted their over-reliance on contractors to troubleshoot. Specific functions mentioned included graphics/overlays, terrain analysis and reports (both free text and pre-formatted), fire mission processing and analysis, and building units high value targets. FBCB2 operators said SA, send and receive, navigation, and identifying friendly/enemy targets were specific functions that training should focus on.

Question 8 – "Do you think you had adequate training to use the system?"

Summary. The majority (seven) of the respondents said they did not have enough digital training for a combat environment. Most acknowledged the training they received was of high quality, but insufficient quantity. Six Soldiers mentioned the training needs to be more in-depth and job specific. One participant said he was very well trained on FBCB2 prior to deployment, but he had no training for the system he actually used while deployed.

Question 9 – "Is there anything that is not taught in digital training that you think should be?"

Summary. Only four participants responded to this question. Issues mentioned included troubleshooting, connectivity problems, and more specific training on tactics to use in the deployed area.

Question 10 – "Are there any post-training support tools you would like to see, such as on-line tutorials, refresher training, checklists, procedural guides, or the like?"

Summary. Nine respondents said procedural guides and refresher training would be most useful. Several stressed the guides should be easy to read and use, such as a quick-reference guide or checklist. One Soldier suggested a Technical Manual (TM) -like guide that stays with the system.

Question 11(Question 14 – FBCB2 questionnaire) – "How well does digital training relate to your MOS?"

Summary. All but one participant responded that digital training relates “fairly well” or “very well” to their MOS. Verbal responses included, “It is the most important thing we do,” and “...It’s difficult to imagine being over-trained in this area.”

Question 12 (Question 15 –FBCB2 questionnaire) – “Is there anything else you would like to say about digital training?”

Summary. Approximately half of the Soldiers responded to this question. The consensus was that digital training is helpful, but there needs to be more initial training as well as refresher training. One respondent said [FBCB2] training should be standard for all combat vehicle crews.

Although this question asked about digital training, several Soldiers took the opportunity to comment on the digital systems themselves. It is apparent from their comments that they believe digital systems are useful and necessary, but need to be more user-friendly and reliable.

Additional FBCB2 Questions

Several additional questions were added to the FBCB2 questionnaire. Two of these questions asked whether paper-based tools and references available to FBCB2 operators and leaders were familiar to the respondents, while the third asked how often the FBCB2 drivers display function was used.

Question 11 – (FBCB2 questionnaire) “Are you familiar with the ‘FBCB2 Exploitation Tool’?” (a paper-based aid).

Of the three respondents, none reported they had heard of it.

Question 12 – (FBCB2 questionnaire) “Are you familiar with the ‘Leaders Primer for Exploiting FBCB2’?”

One out of three participants said they had seen this tool, but not read it or used it. The other two reported they had never heard of it.

Question 13 – (FBCB2 questionnaire) “Did your vehicle have an FBCB2 Driver’s Display?” “If so, how often did you use it?”

Again, one out of three Soldiers said they had seen this tool, but not used it. The other two reported they had never seen it.

Discussion

The purpose of this research was to identify how Soldiers employed digital C3 systems in an operational context, and use this information to revise formal training courses to more closely reflect actual usage.

Usage Patterns of Digital Functions

Frequently used functions. Of the 13 functions used “occasionally” or more often, eight were used “occasionally,” two were used “often,” and three were used “most of the time.” Table 3 summarizes these data. Interestingly, even though “Create/send/receive orders,” and “Check location of key support points” were rated as easy to learn and use, more Soldiers preferred to perform these functions manually than use digital means. The reason for this is unclear, but it may be that they were more familiar with performing these functions manually and therefore preferred the manual means of performing the function.

Of the remainder of functions, only three are used “most of the time” and they are classic C3 functions; “Develop plans and orders,” “Create/send/receive graphics/overlays,” and “Check location of friendly units from your unit.” In addition, “Create/send/receive reports,” and “Plan routes” (for FBCB2) were used “often.” These are the five functions Soldiers reported they used most often. Eight more functions were used “occasionally.” Four were common functions and four were FBCB2 specific.

As Table 3 shows, of the functions that were used most often, two were rated hard to learn (“Create/send/receive graphics/overlays,” and “Develop plans and orders”) but easy to use. One was rated easy to learn but hard to use (“Plan routes”), and another (“Create/send/receive reports”) was “very easy” to learn and “easy” to use.

Table 3. *Frequently Used Functions*

Function	Digital Preference	Frequency of Use	Difficulty Learning	Difficulty Performing
Create/send/receive graphics/overlays	Digital	Most of time	Hard	Easy
Develop plans and orders (TOC specific)	-	Most of time	Hard	Easy ^a
Check location of friendly units (from your unit)	Digital	Most of time	Very easy	Easy
Plan routes (FBCB2) ^b	Digital	Often	Easy ^a	Hard ^a
Create/send/receive reports	Digital	Often	Easy	Easy
Navigate routes (FBCB2) ^b	Digital	Occasionally	Hard	Hard
Navigate in complex/urban terrain (FBCB2) ^b	Digital	Occasionally	Hard	Hard
Create/send/receive orders	Manual	Occasionally	Easy	Easy
Create/send/receive free text messages	Digital	Occasionally	Easy	Easy
Check location of other areas of interest	Digital	Occasionally	Easy	Easy
Avoid firing on friendly units (FBCB2) ^b	Digital	Occasionally	Easy ^a	Easy ^a
Check location of key support points (FBCB2) ^b	Manual	Occasionally	Easy ^a	Easy ^a
Check location of friendly units (from other units/allies)	Digital	Occasionally	Very easy	Easy

^a No mode established; rating based on mean

^b Rating based on N = 3

Unused functions. Soldiers who participated in this research reported they used about one half of the digital functions available to them. The other half of functions were rarely, if ever, used. There are a number of possible reasons for this use pattern.

First, it may be that many of the functions available were not relevant to the mission. Digital systems tend to be designed for maneuver warfare. Therefore, since peacekeeping operations rarely call for the use of massed artillery, functions such as "call for fire" may not be used often. Second, it may be that Soldiers were not confident in their ability to use the function correctly, either because they did not learn it well or forgot how to use it, and so employed manual means. A third possibility is that they found the functions too hard to use digitally and instead performed the functions manually. Finally, it may also be that some functions were not used because doctrine and techniques for integrating these functions into combat operations have not been fully developed.

It may also be that the functions used most often were more critical to the mission and the functions used less often were less critical. The issue of function criticality was not addressed by this research; all functions were assumed to be equally critical. However, it might be an issue to consider in future research.

Although there are no explicit data that indicate which of these reasons are relevant to why Soldiers do not use a particular digital function, the pattern of answers may give us a clue. Presumably, those functions that Soldiers said they rarely used but were easy or very easy to learn and use were not often performed because they were not relevant to the type of operation. On the other hand, functions that were rated as hard to learn or use may not have been employed often because Soldiers found it easier to perform the function using manual means. Using this assumption, of the 25 functions Soldiers reported they rarely used, six were rated as easy to learn and easy to use, while the remaining 19 were either hard to learn, hard to use, or both. Table 4 shows those functions that were used infrequently but easy to learn and use; Table 5 lists those that were rarely used and hard to learn or use.

Table 4. *Infrequently Used Functions Rated as Easy to Learn and Use*

Function
Perform terrain analysis
Check trafficability of routes
Check location of enemy units
Synchronize tasks between units (TOC specific)
Use reminders (FBCB2 specific)
Use alarms (FBCB2 specific)

Table 5. *Infrequently Used Functions Rated as Hard to Learn or Use*

Function	Learn	Use
Call for support (general)	Easy	Hard*
Distribute graphics/overlays ^a	Hard	Hard
Report logistics status	Easy	Hard*
Report personnel status	Easy	Hard*
Check location of civilians	Easy*	Hard
Check location of obstacles	Easy	Hard
Check personnel status of your units	Easy	Hard*
Check logistics status of your units	Easy	Hard*
Check supplies available at CSS location	Hard	Very Hard*
Check that units are following plan/branches/sequels	Hard	Very Hard*
Distribute plans and orders (TOC specific)	Very Easy	Hard
Coordinate plans and orders (TOC specific)	Easy*	Hard
Synchronize support actions (TOC specific)	Hard	Easy*
Manage logistics (TOC specific)	Hard*	Hard
Manage personnel actions (TOC specific)	Easy*	Hard
Distribute other data (FBCB2 specific) ^a	Hard*	Hard*
Call for fire (FBCB2 specific) ^a	Hard*	Hard*
Use task management tools (FBCB2 specific) ^a	Hard*	Hard*
Navigate in low visibility (FBCB2 specific) ^a	Hard*	Hard*

* No mode established; rating based on mean

^a Rating based on N = 3

Using FBCB2 for navigation. FBCB2 is unique among ABCS systems in that it can be used for navigating individual vehicles. The few Soldiers who reported using these functions said they used them only occasionally, but were split on whether it was easy or hard to use. However, they said they rarely used the navigation function to navigate in low visibility, and they agreed that this function was hard to learn and hard to use.

Free response questions. The Soldiers who responded to the free response section mentioned a number of items related to individual digital systems, but there were also certain commonalities. One common theme was the Soldiers said the training they received was good, but they did not receive enough in-depth training to feel confident using the systems in a combat environment. Another recurring theme was they feel they need more training in troubleshooting and maintaining connectivity.

Recommendations for Training

Readers should note that training is only one element in total system usability. Other factors affect digital performance as well. For example, there is a lack of common standard operating procedures (SOP) and tactics, techniques, and procedures (TTP) for digital operators and leaders ("Commanding a Digital Brigade Combat Team," 2001). Also, several Soldiers mentioned the need for more training in troubleshooting and maintaining the network. Improvements in network reliability would decrease Soldier workload and increase system usability. In addition, there were a number of functions Soldiers rated as difficult to perform. If these could be redesigned so they assist the Soldier in performing tasks and reduce unnecessary workload, system usability would improve.

Given the limitations listed above, there are ways training can improve Soldier usability of digital systems. Several Soldiers reported in the free-response section that they felt training did not go into sufficient depth. This is not surprising since training time is at a premium and there is a considerable amount of training required. However, training developers and instructors may consider focusing on those functions which are used often, particularly the ones which are hard to learn or hard to use, such as working with graphics and overlays, planning tasks, and reporting tasks, as well as additional emphasis on troubleshooting. Although Soldiers should be familiar with all functions, they should be more familiar with the functions they will use most often in an operational environment. In this way, training can go into more detail on those functions used most often.

In addition, consideration might be given to developing paper-based aids such as procedural guides and checklists that can be given to Soldier attending digital training to take with them for use in the field. Several Soldiers mentioned having to refresh their memory on how to perform infrequently-used functions. Such guides would only need to be "memory joggers" consisting of short, telegraphic style sentences to remind Soldiers of the order of tasks, similar to the checklists used in aviation. If such paper-based aids become popular with Soldiers, they can also be made available for download from web sites.

Another implication for training (noted by a reviewer of this research) is that if Soldiers are unsure of which system or version they will use in the field, then it may be best for institutional training to focus on general principles and strategies for employing digital systems, rather than specific procedures. Training on operation of the digital system itself would be accomplished in the field, perhaps by embedded training or tutorials.

Conclusion

This research presents a picture of how leaders and Soldiers use digital C3 systems in an operational environment. Although there were relatively few respondents, the data show some interesting findings. The majority of work with digital C3 systems involves just a few functions that are classic C3 planning and reporting tasks. Most of the remaining functions are used only rarely. This information can be useful for training developers and instructors to decide how to allocate valuable training time.

References

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Appendix A

Acronyms

AFATDS	Advanced Field Artillery Tactical Data System
AMDWS	Air and Missile Defense Warning System
ASAS	All Source Analysis System
BCTC	Battle Command Training Center
C3	Command, Control, and Communications
COP	Common Operational Picture
CSS	Combat Service Support
EDI	Electronic Data Interchange
FAARP	Forward Area Arming and Refueling Point
FBCB2	Force XXI Battle Command, Brigade and Below.
OIF	Operation Iraqi Freedom
MOS	Military Occupational Specialty.
OPNET	Operator new equipment training
PC	Personal Computer
SA	Situation Awareness
SOP	Standard Operating Procedures
TM	Technical Manual
TOC	Tactical Operations Center.
TTP	Tactics, Techniques, and Procedures

Appendix B

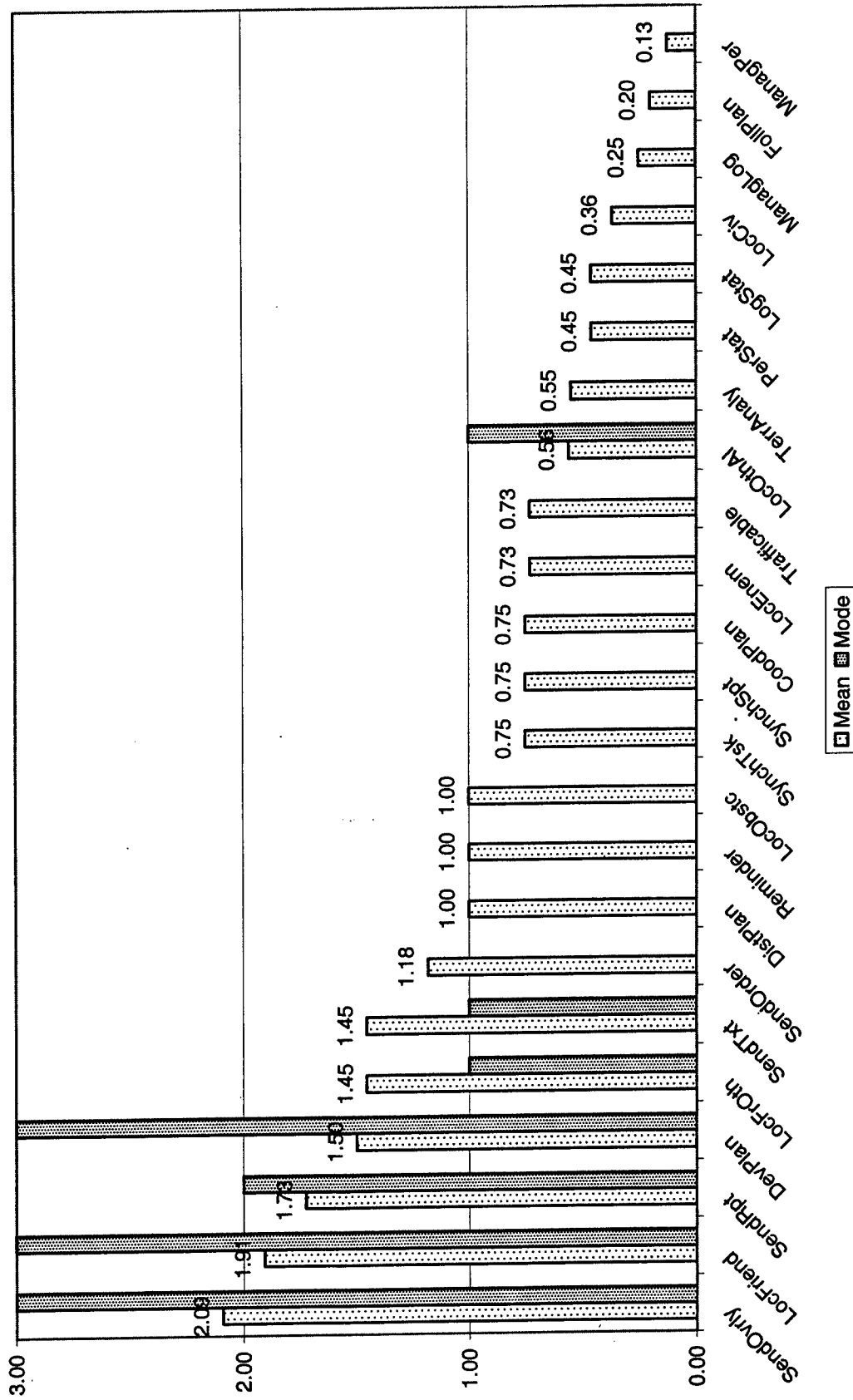
Graphs of Results

<i>Graph B-1. Frequency of Use</i>	B-2
<i>Graph B-2. Difficulty in Learning to Use Function.....</i>	B-3
<i>Graph B-3. Difficulty Performing Function</i>	B-4

Function Labels used on Graphs B-1 through B-3

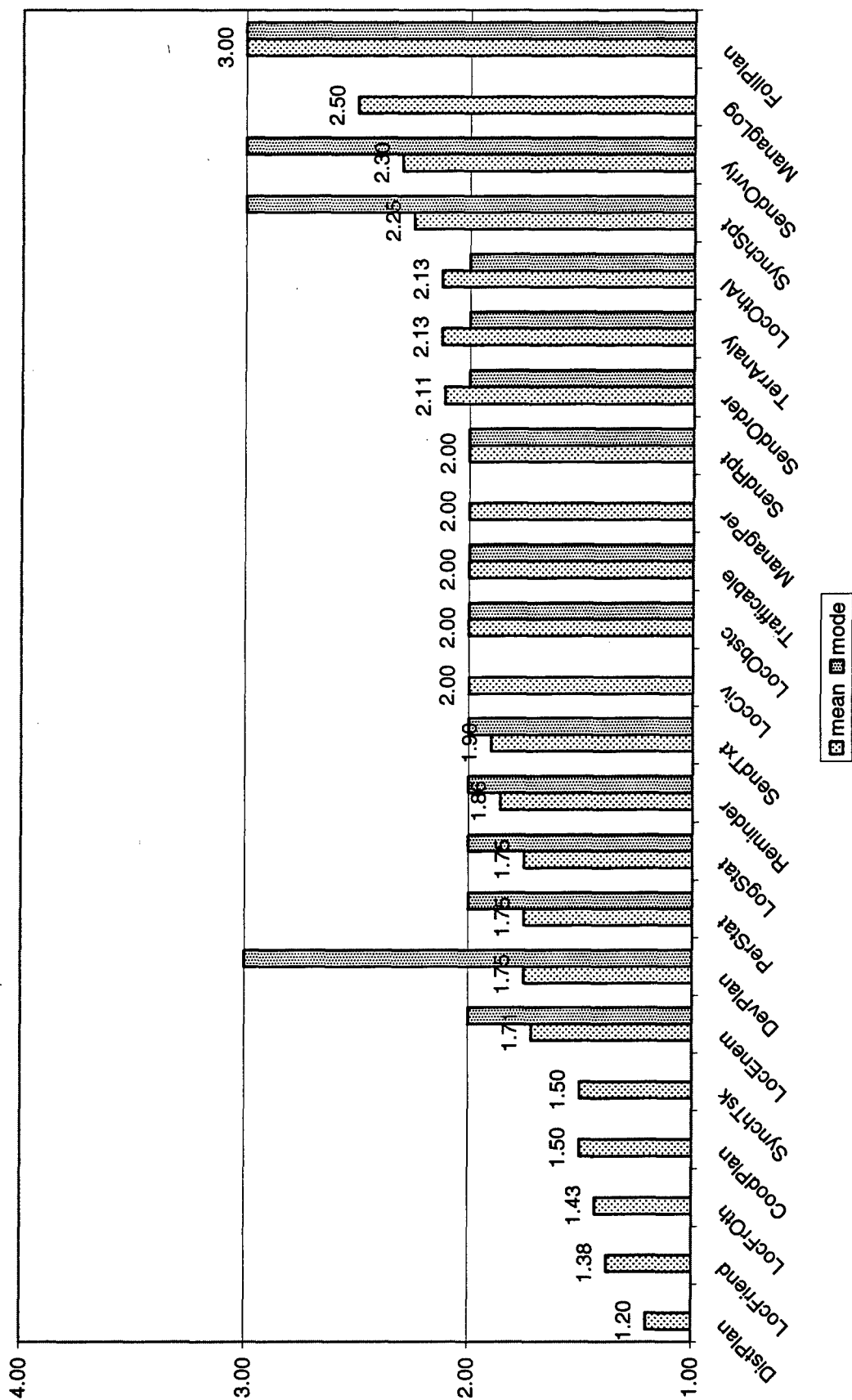
Function Label	Digital Functions
CoordPlan	Coordinate plans and orders
DevPlan	Develop plans and orders
DistPlan	Distribute plans and orders
FollPlan	Check that units are following plan/branches/sequels
LocCiv	Check location of civilians
LocEnem	Check location of enemy units
LocFriend	Check location of friendly units (from your unit)
LocFrOthr	Check location of friendly units (from other units/allies)
LocObstc	Check location of obstacles
LocOthAI	Check location of other areas of interest (not covered above)
LogStat	Check logistics status of your units
ManagLog	Manage logistics
ManagPers	Manage personnel actions
PerStat	Check personnel status of your units
Reminder	Use reminders
SendOrder	Create/send/receive orders
SendOvrly	Create/send/receive graphics/overlays
SendRpt	Create/send/receive reports
SendTxt	Create/send/receive free text messages
SynchSupt	Synchronize support actions
SynchTsk	Synchronize tasks between units
TerrAnaly	Perform terrain analysis
Trafficable	Check trafficability of routes

Graph B-1. Frequency of Use



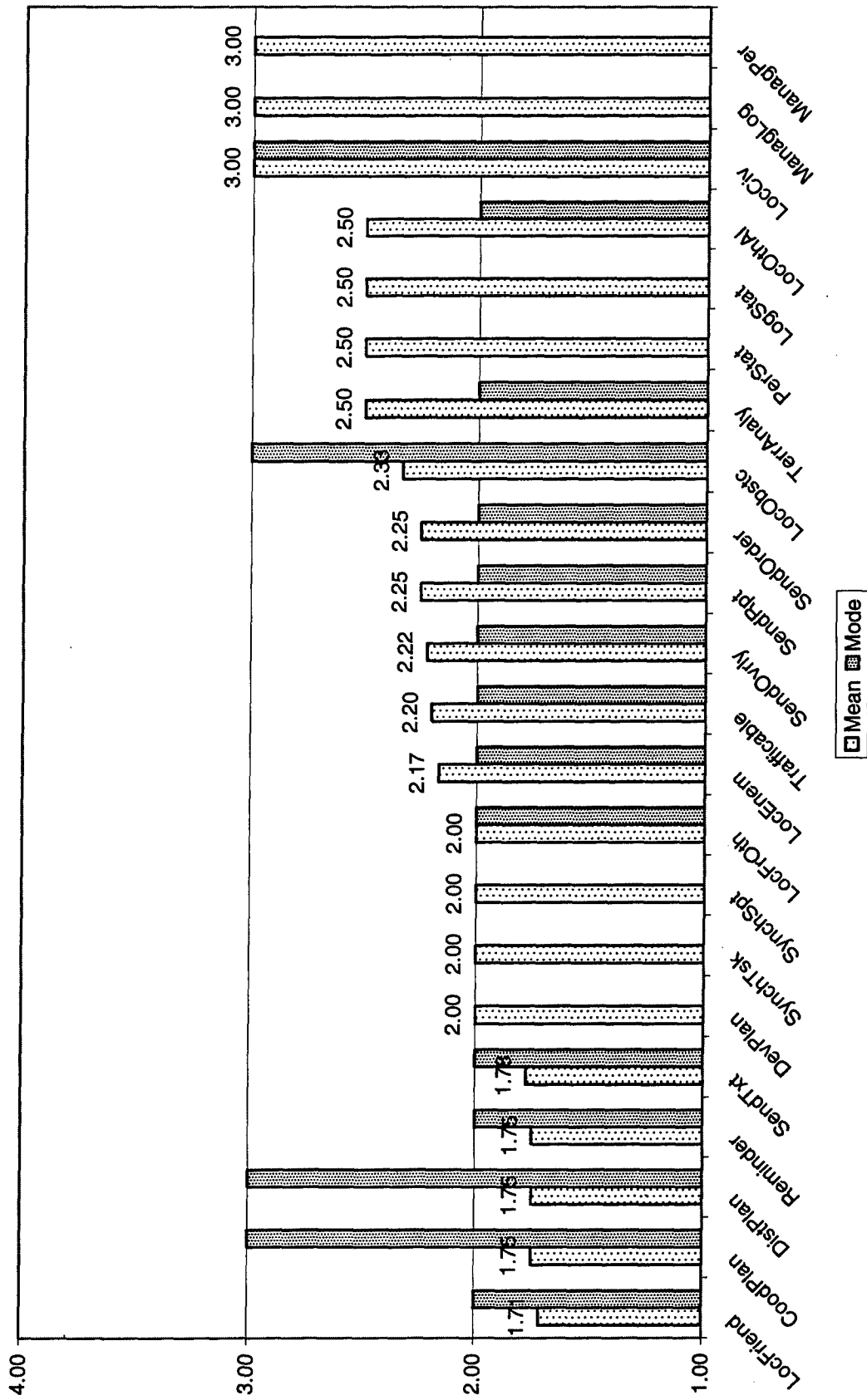
Note: A higher bar indicates greater frequency of use. The functions are ordered from greater to lesser use, with functions that are used more frequently on the left. For functions where there is no mode shown, the mode is zero.

Graph B-2. Difficulty in Learning to Use Task



Note: In the graph, a higher bar indicates the function was more difficult to learn, and the functions are ordered from least to most difficulty, with the less difficult functions on the left. Where no mode is shown, the mode is zero.

Graph B-3. Difficulty Using Task



Note: Functions are ordered with easiest on the left and hardest on the right. A higher bar indicates the function was more difficult. The reader should note well that for this question there were no functions with a mode of zero. Unlike the other figures, if no bar is shown for mode, there were too few respondents for a mode to be calculated.

Appendix C

Soldier Responses to Free Response Questions

Question 5 – “Were there any functions you would have like to use but didn’t’ because you didn’t know how? If so, which ones?”

Participant 101. N/A

Participant 102. No

Participant 103. Judging from the various capabilities of Falcon View (imagery program), I suspect we did not exploit it as much as we could have. Not knowing what these capabilities are, it is impossible to know what we missed out on. For example, capturing images then copying and pasting images to PowerPoint to add icons, text, symbols, etc.... If these could have been in Falcon View itself, it would’ve saved many hours.

Participant 104. N/A

Participant 105. – There were functions that would have been more useful that was not part of the system; Falcon view had parts to it that would have been nice to have instead of ASAS heavies. It was nice to still be able to input data while the server was down using laptop and Falcon View. Then when the LAN server was back up the products could then be posted.

Participant 106. N/A

Participant 107. N/A

Participant 108. No

Participant 201. N/A

Participant 202. Sequels

Participant 203. I was never fully trained on this system, so there were many functions I was not able to do. And probably more that I didn’t know about functions I used I was able to pick up on quickly.

Question 6 – “Were there any digital procedures you forgot how to use if you didn’t use them often enough? Which ones? Did you use any reference (such as the on-line tutorial or software user’s guide) to remember?”

Participant 101. – Most of the skills required to properly operate AMDWS are perishable. For example, configuring the EDI node initialization, proper start up and trouble shooting procedures will be forgotten easily. I had to use the references and the help guide.

Participant 102. – No

Participant 103. - I had forgotten how to use the terrain analysis tools. I referenced a software user’s guide and digital operators guide to re-learn/ refresh my proficiency.

Participant 104. – Developing a plan of action – software user’s guide is too in-depth to find needed resources fast.

Participant 105. N/A

Participant 106. – There are always procedures that are forgotten if not used. One is keeping passwords current, Used notes mostly.

Participant 107. N/A

Participant 108. – Setting up AFATDS to receive targets for Q-36 and Q-37 radars

Participant 201. Call for fire, Call for support, Navigation in low visibility

Participant 202. Graphic overlays, call for fire, most of the time the heat and reprogramming of tank hindered operations.

Participant 203. - Call for fire, Send/ Receive map overlays. – I did not use any reference tools.

Question 7 – “What part of operating digital systems should digital training focus on?”

Participant 101. – Trouble shooting! In the field, we spend more time setting up, troubleshooting, than we actually required to perform the function. The course should cover the many “what ifs” scenarios, it should cover from basic power up problems to tracing the network cable.

Participant 102. - The communications aspect is the most difficult part. Getting the system to talk and transfer data often takes longer than its worth due to slowness of the ATCC's systems and inherent snags in our communication protocol's.

Participant 103. - As far as it pertains to 96B's graphics/overlays, terrain analysis and reports (Free text and pre-formatted).

Participant 104. – Fire mission processing and analysis. Building units high value targets

Participant 105. N/A

Participant 106. – all the ones that we as operators do not get the chance to use during normal training that we might have to know while being masters, that at as is way to communicate with higher and not having contractors available at the most critical times.

Participant 107. N/A

Participant 108. - Training operators more often.

Participant 201. - Situation awareness, send and receive

Participant 202. Continuous hands on training at the lowest level

Participant 203. Navigation (including identifying friendly/ enemy targets).

Question 8 – “Do you think you had adequate training to use the system?”

Participant 101. – I am quite knowledgeable in computer operations. So, most tasks that include a keyboard, CPU, and a set of instructions and task I can figure out. But as for the training I received during the 40 hr class, it just covered the bare basics of operations. It is not enough to send a group of Soldiers to war with.

Participant 102. – No, most of it is self taught. The online/built-in manuals either don't go deep enough or are too weighted down with words (overwritten)....

Participant 103. - Slightly less than adequate training equaled more stress in self-learning the necessary functions. Results, however, proved to be more than adequate in fulfilling the specific task of capturing HVT#1.

Participant 104. - No. Training was general to be very good. Needs to be more in-depth and job specific. i.e. Paladin training should be separate from MLRS training

Participant 105. - No. I was not trained at all on MCS-L. I learned it all from watching and OJT. I was very well trained on FBCB2 prior to deployment.

Participant 106. Overall yes. But we always need to train and focus more on our particular jobs. After all, we can't be good at what we do if we are not training on scenarios of our jobs. Yes, we still need the basics, but we still need in-depth training on each individual job.

Participant 107. Yes- with supervision. I'm recently out of AIT and feel comfortable but to be shown how to use it in a combat environment vs. a classroom

Participant 108. I received my training using the AFATDS in warfighters, UFL's, etc....

Participant 201. No

Participant 202. No

Participant 203. No

Question 9 - "Is there anything that is not taught in digital training that you think should be?"

Participant 101. N/A

Participant 102. - Rarely do we game play the entire digital tactical scenario. We aren't taught in class the actual issues that come when you try to interface an ARATDS to a SINCGARS or an FBCB2 to an EP/RS or even to send traffic between ATCC's systems like AFATDs and FBCB2.

Participant 103. N/A

Participant 104. N/A

Participant 105. Troubleshooting is the single most important skill in dealing with digital systems, especially FBCB2. This topic should be standard even at the operation level. This training should include work arounds, maintenance, and ways to improve the effectiveness of the training.

Participant 106. - More training on [guerilla] warfare would have been more helpful in OIF. More urban training and reacting and expecting the unexpected. Training on things not normally thought of.

Participant 107. N/A

Participant 108. Working more with fire-finding radars.

Participant 201. N/A

Participant 202. N/A

Participant 203. N/A

Question 10 – “Are there any post-training support tools you would like to see, such as on-line tutorials, refresher training, checklists, procedural guides, or the like?”

Participant 101. N/A

Participant 102. - PROCEDURAL GUIDES would help a lot...Currently we haven't seen one in 3 years for some systems.

Participant 103. - Online tutorials (or on available CD-ROM) would be great. - Refresher training-at regular intervals-would be a boon.

Participant 104. - Make an easier reading software guide (Chemistry is easier)

Participant 105. - Both FBCB2 and MCS need a TM- like manual that stays with the system and can be easily understood at the lowest level.

Participant 106. - Yes. Always refresher training. We have a unique opportunity to gather all facts and data and try and come up with checklists, procedures, and guides to overcome and better protect against counter measures for terrorist attacks. We do not take the intel seriously enough. After a major incident, there would have been intel before hand, but not taken seriously enough to develop more protect-able measures.

Participant 107. - Procedural Guides

Participant 108. - Refresher training and more procedural guides.

Participant 201. - Refresher training, checklist

Participant 202. - Refresher training, checklist

Participant 203. - A quick reference guide with all common FBCB2 tasks easily illustrated

Question 11(Question 14 – FBCB2 questionnaire) – “How well does digital training relates to your MOS?”

0 – Not at all 1 – Not very well 2 – Fairly well 3 – Very well

Participant 101. - 3

Participant 102. - 2 Its just [too] sterile and doesn't go deep enough as far as the classroom side of the house is concerned.

Participant 103. - 3 As 96B's, it's difficult to imagine being over-trained in this area. As much training and refresher training as can be offered would directly affect our ability to excel at our job.

Participant 104. - 2

Participant 105. - 2 – Focus on basics, Time is wasted on explaining functions never used (i.e. perstat, NBC. recovery) – Conduct training on actual systems not computers. – Create a CD-ROM tutorial that can be viewed on any laptop.

Participant 106. - 3 Digital training has helped out my MOS by helping to get information disseminated more quickly as long as it stays working.

Participant 107. – 2

Participant 108. – 3 It is the most important thing we do.

Participant 201. – 1 It can pinpoint friendly forces not in sight, controlling the need to move into dangerous position to locate platoon

Participant 202. – 2

Participant 203. – 3 As an indirect fire infantryman, FBCB2 makes reconning mortar positions and routes easier. It also, gives a proper standard for call for fire missions allowing more accurate and faster fire missions.

Summary. All but one participant responded that digital training relates “fairly well” or “very well” to their MOS. Verbal responses included, “It is the most important thing we do,” and “...It’s difficult to imagine being over-trained in this area.”

Question 11 – (FBCB2 questionnaire) “Are you familiar with the ‘FBCB2 Exploitation Tool’?”

0 – Never heard of it 1 – I’ve seen it 2 – I’ve read it 3 – I’ve used ideas from it

Participant 201. – 0 Never heard of it

Participant 202. – 0 Never heard of it

Participant 203. – 0 Never heard of it

Question 12 (Question 15 –FBCB2 questionnaire) – “Is there anything else you would like to say about digital training?”

Participant 101. N/A

Participant 102. - Our computers are too slow for the software they run systems don’t interface well, Radars AFATDS FBCB2 and they just may be a tad bit windows heavy. About 4 windows to visit per function Bat practical. That’s why we didn’t use any of them for planning.

Participant 103. N/A

Participant 104. - It’s needed in the right direction, but if it needs a lot more work = AFATDS software needs to be more user friendly.

Participant 105. – Remove FBCB2 and replace with BLUFOR tracker. FBCB2 is too fragile and has too much reliance on the EFLRS system. – Understand the some actions will always be analog/voice. Remove these. – Some functions are not robust enough to do their job (i.e. supply request many lack many basic items and are thus useless to send digital). – Create ability to export MCS to PowerPoint. – Include satellite graphics as an option on MCS. – Issue Falcon View at troop/ company level.

Participant 106. Digital training has made doing my job much easier and quicker. We have more information with fewer tasks. We first need more individuals to [cycle] through it all 24 hours/ 7 days a week. Burnout happens very quickly and not as accurate of a job is done.

Participant 107. N/A

Participant 108. A lot more of it needs to be done!!! Please

Participant 201. N/A

Participant 202. N/A

Participant 203. Training should be standard for all combat vehicle crews with refresher courses more often. The system I used had only one major flaw, and that is the dependence on other systems in the area to be fully operational. When one system was down, it made all the others less effective.

Question 12 – (FBCB2 questionnaire) “Are you familiar with the ‘Leaders Primer for Exploiting FBCB2’?”

0 – Never heard of it 1 – I’ve seen it 2 – I’ve read it 3 – I’ve used ideas from it

Participant 201. – 0 No

Participant 202. – 0 No

Participant 203. – 1 Yes

Question 13 – (FBCB2 questionnaire) “Did your vehicle have an FBCB2 Driver’s Display?” “If so, how often did you use it?”

Participant 201. – Yes

Participant 202. – No

Participant 203. No